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71. Applicant:

VEB Kombinat Medizin- und Labortechnik Leipzig, DDR 7033 Leipzig, DD

74. Agent:

Steindorf, G., DDR 7035 Leipzig

72. Inventor:

Stiegler, Frank, Dipl.-Ing., DDR 7034 Leipzig, DD; Hoffmann, Jürgen, Dipl.-Ing., DDR 7010 Leipzig, DD; Horn, Hans-Jürgen, Dipl.-Ing., DDR 7030 Leipzig, DD

54. Circuit configuration for the electronic control and monitoring of a respiratory gas humidifier

This invention relates to a circuit configuration for the electronic control and monitoring of a respiratory gas humidifier, the electrical heating device of which is connected by means of a temperature controller with two temperature sensors, of which the one temperature sensor is located close to the patient and the other temperature sensor is located close to the heater. He object of the invention is to electronically adjust the temperature of the respiratory gas, to report the temperature immediately and to display this information by means of a light strip display. The information also includes a limit-value monitoring that is displayed by a color identification as well as a visual and acoustical alarm. The invention teaches that the temperature control has a multiple comparator circuit which is connected by amplifiers and measuring bridges with the temperature sensors and is in communication with a diode row formed from light-emitting diodes, which is concatenated with a flash generator and an alarm generator by means of transistor combinations.

Claims

1. Circuit configuration for the electronic control and monitoring of a respiratory gas humidifier, the electrical heating device of which is connected via a temperature controller with two temperature sensors, of which one temperature sensor is located near the patient and the other temperature sensor is located near the heater, wherein the temperature controller has a multiple comparator circuit (3) that is provided with a voltage divider (5) and is connected via a first amplifier (1) and a measuring bridge (23) that is supplied with a constant current with the temperature sensor (15) located near the patient, and via a second amplifier (2) and a second measuring bridge (24) that is supplied with a constant current with the temperature sensor (16) located near the heater, and is in communication with a diode row[1] (12/1, 12/2, 12/3) which is formed by light-emitting diodes and is connected directly to a temperature selector switch (17), to a transistor combination (7/1, 7/2) and to an additional transistor combination (8/1, 8/2), which are concatenated on one hand with the output transistor of an optical coupler (14) that is connected with the heater (26), with a flash generator (10) and with an alarm generator (11).

2. Circuit configuration as recited in Claim 1, wherein the multiple comparator circuit (3) is connected on one hand with the flash generator (10) and a transistor (21), and on the other hand with a light-emitting diode (12/1) that is concatenated with the transistor (21), and which for its part has a connection with the measuring bridge (24) and the amplifier (2).

3. Circuit configuration as recited in Claims 1 and 2, wherein the light-emitting diode (12/1) and the diode rows (12/1, 12/3) that are realized in the form of light-emitting

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[1] Translator's Note: The German says "Diodenzelle" - literally "diode cell" - although in the rest of the patent it identifies the same item as "Diodenzeile" - "diode row". The translation assumes that "...zelle" is a typographical error for "...zeile".

diodes are LED diodes of the prior art, which by their arrangement in rows form light strips with different color identifications.

4. Circuit configuration as recited in Claims 1 to 3, wherein the multiple comparator circuit (3) is concatenated with a transistor (9), by means of which a connection is created on one hand with the gate (25) that is connected with the flash generator (10) and on the other hand with diodes (20) and via the latter with the light-emitting diode (12/1).

5. Circuit configuration as recited in Claims 1 to 4, wherein the alarm generator (11) that is connected with the transistor combination (3/1, 3/2) is concatenated on the input side with a diode (18).

6. Circuit configuration as recited in Claims 1 to 5, wherein the amplifier (1) is connected via a line (22) directly to the transistor combination (7/1), which is in concatenated with the transistor (7/2) and the optical coupler (14).

Circuit configuration for the electronic control and monitoring of a respiratory gas humidifier

Field of the invention:

The invention relates to a circuit configuration for the electronic control and monitoring of a respiratory gas humidifier, the electrical heating device of which is regulated by a controller by means of a temperature sensor that is located close to the patient. Respiratory gas humidifiers are intended to be used for the artificial respiration of a patent, and are constructed so that in the end of the respirator gas line near the patient, i.e. at the input to the patient, the humidified and temperature-controlled respiration gases have a relative humidity of 96 to 100%.

Characteristics of the solutions of the prior art:

The prior art describes an apparatus for supplying patients with moist respiratory air, in which the amount of heat delivered to the respiratory gas line is controlled by a temperature controller

which receives a sensor signal, such that at the end of the line, the temperature is lower and the relative humidity is higher than the temperature and the relative humidity in the evaporation chamber (DE-OS 23 45 677). This heating and humidification of the respiratory gas can also be performed by a respiratory gas of the bubbler type, in which the dry respiratory gas is injected into a heated water bath, and the temperature of the controller for the regulation of the heater line is controlled as a function of the exit temperature of the humidified and temperature-controlled gas is located in the patient-side end of the hose (DE-PS 25 12 607). The prior art also describes a respiratory gas humidifier with a vaporizer which is located in the housing, whereby the vaporizer is provided below the surface of the water with a heater cartridge that keeps the water boiling, and is provided with a mixing chamber above the surface of the water. Connected to this vaporizer is a respiratory gas feed line and a respiratory gas discharge line, into which a superheater is integrated downstream of the vaporizer, and the heater elements of the superheater are likewise controlled by a temperature sensor that is located slightly in front of the mouthpiece for the patient (DE-PS 27 02 674). The prior art also describes a vaporizer humidifier with a heating element that is isolated from the liquid container, whereby the heating element can be controlled electronically and delivers respiratory gases to the patient with a relative humidity of 100% at a temperature of approximately 25 to 40 degrees C (DE-OS 28 32 225). The continuous flow quantity can thereby be between 1 and approximately 60 l per minute, and the maximum respirator flow quantity can be approximately 10 to 100 liters per minute, the pressure gradient in the humidifier is approximately 0.1 cm column of water at a continuous flow quantity of 30 liters per minute.

This solution also initially assumes that the respiratory gas humidifiers can in general be atomizers or devices that atomize droplets, humidifiers that form bubbles or vaporizer humidifiers, of which the last named are the most widely used, on account of their demonstrated

advantages. The advantages lie in particular in the higher humidity per unit of volume that can be achieved, without thereby generating water droplets. The reason given is that water droplets not only have a traumatic effect in weakened patients, but can also represent a carrier for microorganisms in the respiration device.

On a vaporizing humidifier of this type, a humidifying chamber with a vaporizing element is required, the chamber of which is either enclosed tightly by a heating element, or the vaporizing element is provided with a heating element. This heating element is preferably equipped with an electronic control device to monitor the temperature of the thermal transmission surface and to turn off the vaporizing humidifier if the temperature exceeds a specified level. This task which is to be performed by the electronic control system requires that the temperature sensor be fastened directly to the heating element, so that it makes it possible for the electronic controller to turn the electrical input of the heating element on and off cyclically for short periods of time, to thereby regulate the temperature within narrow limits. However, the location of this temperature sensor does not preclude the possibility that an additional measurement sensor, e.g. a thermistor, may be necessary to measure the temperature of the respiratory gas near the patient and to also perform a monitoring function, and turn off the heating element in the event the specified temperature level is exceeded. Along with the shutdown initiated by this measurement sensor, an acoustical and visual alarm system is also actuated. In addition to the temperature sensor that is fastened to the heating element and the measurement sensor that is located near the patient, a thermal cut-out is provided as an additional protection means, which is actuated in the event of an excessive increase in temperature and if the current feed to the vaporizer humidifier is interrupted. Such safety measures for the patient are also important in another heated respiratory gas humidifier, where an overheating in the system triggers a visual

and acoustical alarm and likewise, with this alarm, the heater of the respiratory gas humidifier is automatically turned off (Brochure from 3M Deutschland GmbH on the Model 32 04 G respiratory gas humidifier). This unit, which is designed for a wide range of operations, however, has the additional advantage that a visual display of the proximal temperature of the airway is guaranteed by a digital display. But even then, the respiratory gas humidifiers developed so far could only be considered satisfactory if, in addition to the stepwise adjustment of the respiratory gas temperature within the range required for proper respiration and an easily understood visual display the respiratory gas temperature at the point of delivery to the patient, it is also possible to display any temperature above or below the operating range of the respiratory gas temperature, as well as to signal defects, malfunctions or improper operation, including when the respiration unit is connected.

Object of the invention:

The object of the invention is to realize these functions that are still lacking, to achieve an even better display of the temperature and to optimally configure the information monitoring of the temperature of the respiratory gas that is delivered to the patient.

Teaching of the invention:

The task the invention has set for itself is to develop a circuit configuration for the electronic control and monitoring of a respiratory gas humidifier that makes it possible to set a respiratory gas temperature electronically to report the selected temperature directly, to display said temperature information by means of a strip light display and to display a temperature above[2] or below the preset limits in the form of a colored indicator, and to ensure a continuous monitoring of the vaporizer temperature on the heat transfer surface, by displaying any temperature in excess of the allowable limit, and also to emit a visual and acoustical alarm.

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[2] Translator's Note: The German text actually says, "... und eine Grenzwertüberwachung bzw. -unterschreitung" - literally "to display a monitoring of the limit value or excessively low value" - although it is obviously a mistake. The translation assumes that "Grenzwertüberwachung" is a typographical error for "Grenzwertüberschreitung", i.e. "a temperature in excess of a limit value". There are similar sloppy-typing mistakes throughout the German text.

The invention teaches that the temperature controller that is connected with the electrical heating device has a multiple comparator circuit that is provided with a voltage divider, whereby the multiple comparator circuit is connected by means of a first amplifier and a first measuring bridge that is supplied with a constant current with a temperature sensor located near the patient and by means of a second amplifier and a second measuring bridge that is supplied with a constant current with a temperature sensor that is located near the heater. said multiple comparator circuit is in communication with diode rows that are realized in the form of light-emitting diodes which are directly connected to a temperature selector switch, to a transistor combination and to an additional transistor combination, which are concatenated on one hand via the measuring bridges with the temperature sensors and on the other hand with the output transistor of an optical coupler connected with the heater device, with a flash generator and with an alarm generator.

In the circuit configuration taught by the invention, in one advantageous configuration the multiple comparator circuit is connected on one hand to the flash generator and a transistor and on the other hand with a light-emitting diode that is concatenated with said transistor, whereby the light-emitting diode, for its part, has a connection with the second measuring bridge and the second amplifier. It is thereby of special advantage if as the light-emitting diodes, LED diodes of the prior art are used that, as a result of their arrangement in rows, form strip lights with different color displays.

In an additional realization, the multiple comparator circuit is concatenated with a transistor, by means of which a connection is established on one hand with a gate that is connected with the flash generator and on the other hand with diodes and via said diodes with the one light-emitting diode. An additional concatenation is provided to turn off the heater device, by connecting the alarm generator that is connected with the one transistor combination on the input side with a diode. An additional possible way to turn off the heater device is via a line that runs from the first

amplifier directly to that transistor combination which is concatenated with the transistor and the optical coupler downstream of it.

Exemplary embodiment

The invention is explained in greater detail below and is illustrated in the accompanying drawings.

As shown in the drawings, the circuit configuration for the electronic control and monitoring of a respiratory gas humidifier consists of a first amplifier 1, a second amplifier 2, a multiple comparator circuit 3 that is connected with said amplifiers 1, 2, and two bridge resistances 4, 6 that are upstream of the amplifiers 1, 2, and a voltage divider 5 that is connected to the multiple comparator circuit 3. On the output side of this multiple comparator circuit 3 there are transistor combinations which are marked with the reference numbers 7/1, 7/2 and 8/1, and an additional transistor 9 which has a direct connection to the multiple comparator circuit 3. This multiple comparator circuit 3 is also connected with a flash generator 10 and via the transistor combination 8/1 with an alarm generator 11. The multiple comparator circuit 3 is also connected with its outputs (4 to 15, 18) to a light-emitting diode 12/1 and two light-emitting diode combinations 12/2, 12/3, which all together are realized in the form of light-emitting diode rows, of which the diode combinations 12/2, 12/3 are concatenated directly with the transistor combination 8/1 and via a temperature selector switch 17 with the transistor combination 7/1. The latter is in connected with the transistor combination 7/2, which for its part is connected to the output transistor of an optical coupler 14. The temperature sensor for the respiratory gas temperature is assigned the reference number 15 and the temperature sensor for the heater temperature is designated 16, and are set to a specified temperature or voltage level by means of the bridge resistances 4, 6.

As also shown in the drawings, between the one output (4) of the multiple comparator circuit 3 ... *[Translator's Note: There may be some text missing here, because there is no indication of between what and what.]* ... there is also a connection to the transistor combination 8/a and via the latter to the transistor 8/2, which is concatenated with a relay 13 and a diode 18. One diode 19 and two diodes 20 are also connected with a measuring bridge 23 that is supplied with a constant current, in which the temperature sensor 15 is also located and which with its output voltage amplifies the amplifier 1. *[Translator's Note: sic, but probably should be "... is amplified by the amplifier 1." See next sentence.]* Likewise the temperature sensor 16 lies in a measuring bridge 24, the output voltage of which is amplified in the amplifier 2. Finally, the amplifier 1 is connected by means of a line 22 directly to the transistor combination 7/1 and the multiple comparator circuit 3 is connected by means of an output (2) with the flash generator 10 and with a transistor 21, which for its part is connected with the light-emitting diode 12/1. The flash generator 10 is also activated by a gate 25, if the voltage is above or below a reference voltage. For this purpose, the one input for the upper limit value (OGW) is concatenated with the transistor 8/2, and the other input for the lower limit value (UGW) is concatenated with the transistor 9.

For the light-emitting diodes or diode rows 12/1, 12/2 and 12/3 and for the diode 19, LDE *[sic - presumably LED]* are used, of which those identified with the numerator 12 can be configured in the form of a strip light, the colors of which can be, for example, yellow for the light-emitting diode 12/1, green for the light-emitting diode 12/2 and red for the light-emitting diode 12/3. Additional properties and advantages of the invention and existing signal concatenations of the circuit configuration are indicated in the following description in connection with the accompanying drawing of the exemplary embodiment.

The illustrated circuit configuration has shown that the temperature sensor 15 which is responsible for the temperature of the respiratory gas lies in a measuring bridge 23 that is supplied with a constant current, the output voltage of which is amplified in the amplifier 1 and

the output signal of which is fed to the multiple comparator circuit 3 via its input (17). Reference voltages for the comparators of the multiple comparator circuit 3 are also provided by the voltage divider 5, which are applied to its inputs (3, 16). It was also noted above that the output (4 to 15) are connected with the light-emitting diodes 12/2, 12/3 and have a connection with the temperature selector switch 17. When the temperature set by the temperature selector switch 17 is reached, the corresponding comparator tips over and an electric current flows via this temperature selector switch 17 to the transistor combination 7/1. This combination, via the transistor combination 7/2, controls the output transistor of the optical coupler 14 at zero current, as a result of which the connected heater device (not shown) is turned off. The diode 19, which has up to then been displaying the heater operation, is thereby extinguished.

The multiple comparator circuit 3 is set to the "band operation" mode by switching its outputs (14, 15) with a defined potential, as a result of which the light-emitting diodes 12/1, 12/2, 12/3 are configured in the form of a strip light. In the operating temperature range, an electric current flows via the diodes 20 and the light-emitting diodes 12/2 into the multiple comparator circuit 3 to the output of the not-yet-tipped stage, as a result of which the green strip lights and indicates the temperature of the respiratory gas. When the voltage falls below the reference voltage for the lower limit value, starting from the output (15) of the multiple comparator circuit 3, via the transistor 9 and the gate 25, the flash generator 10 is activated, which with its output signal actuates the transistor 21, and thus via the diodes 20 and the light-emitting diode 12/1 causes it to flash with an intermittent flow of current. When the voltage exceeds the reference voltage for the upper limit value, starting from the output (4) of the multiple comparator circuit 3, the following processes are triggered via the transistor combination 8/1:

- Via the gate 25, the transistor 8/2 activates the flash generator 10, which via the connection (2) of the multiple comparator circuit 3 causes all the light-emitting diodes or diode rows 12/2, 12/3 to blink;
- the alarm generator 11 with its signal device is activated directly;
- by means of the diode 18, the transistor 7/2 is blocked, which turns off the heater device;
- the relay 13 is switched through, and with its floating contact makes possible the emission of signals to external monitoring devices.

The temperature sensor 16 that is responsible for the heater temperature is set, as described above, with the bridge resistance 6 to a fixed temperature or voltage. When the temperature or voltage exceeds the defined values, an electric current flows from the amplifier 2 to the transistor combination 8/1 and thereby generates the same signals as if the upper limit value were being exceeded.

When the temperature sensor 15 is not connected, the measuring bridge 23 is detuned so that the output signal from the amplifier 1 via the line 22 directly controls the transistor combination 7/1 and via the transistor 7/2 and the optical coupler 14 turns off the heater device.

With this circuit configuration and the integrated multiple comparator circuit 3 and the use of light-emitting diodes 12/1, 12/2, 12/3 on its outputs (4 to 15, 18), the direct connection of a temperature selector switch 17 becomes possible for the setting of respiratory gas temperatures as well as for direct information on the current respiration gas temperature. By setting the multiple comparator circuit 3 to "strip operation", it also becomes possible to realize the individual LED diodes in the form of a strip light, and to use the color of the light strip to create an easy-to-understand display of the temperature when the limit value is exceeded. The optimal information quality can be further enhanced by means of the flashing diode chain of light-emitting diodes 12/2, 12/3.

An additional advantage consists of the combination of the bridge resistance 6 with the temperature sensor 16, as a result of which a low-inertia signaling is guaranteed when the limit value temperature of the heater device is exceeded, e.g. on the cylindrical surface of the vaporizer of the respiratory gas humidifier. Consequently the invention makes possible a correct display and an accurate setting of the temperature of the respiratory gas in the required respiratory range, and a reliable signaling and alarm can be guaranteed in the event the temperature of the respiratory gas is above or below the operating range, whether as a result of defects, malfunctions or incorrect operation. A temperature that exceeds a fixed limit temperature is indicated visually and optically, and the device cannot be started if the respiratory gas temperature sensor is not connected or a wire is broken.

List of reference numbers used:

1	Amplifier
2	Amplifier
3	Multiple comparator circuit
4	Bridge resistance
5	Voltage divider
6	Bridge resistance
7	Transistor combination (7/1, 7/2)
8	Transistor combination (8/1, 8/2)
9	Transistor
10	Flash generator
11	Alarm generator
12	Light-emitting diodes (12/1, 12/2, 12/3)
13	Relay
14	Optical coupler
15	Temperature sensor (respiratory gas)
16	Temperature sensor (heater)
17	Temperature selector switch
18	Diode
19	Diode
20	Diodes
21	Transistor
22	Line
23	Measuring bridge
24	Measuring bridge
25	Gate
26	Heater device